Tracking and Ground-Based Navigation: Precision System Temperature Measurements at Goldstone

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The system operating noise temperature performance of the low-noise research cones at the Goldstone Deep Space Communications Complex is reported for the period October 1, 1972 through January 31, 1973. System temperatures are reported for the S-band radar operational cone at DSS 13, the S-band megawatt transmit cone, and the polarization diversity S-band cone at DSS 14. In addition to these measurements, system temperature calibrations and antenna elevation profiles are reported for the 26-m-diam antenna at DSS 13 with and without the quadripod, and for the 64-m-diam antenna at DSS 14 at S- and X-bands with and without the reflex feed system.

The system operating noise temperature performance of the low-noise research cones at the Goldstone Deep Space Communications Complex is reported for the period October 1, 1972 through January 31, 1973. Most of the operating noise temperature calibrations were performed with the ambient termination technique[1] (Ref. 1). System temperature measurements were made on the following cones:

(1) S-band radar operational (SRO) cone, with maser serial number 96S5 (superconducting magnet) located in the cone, before intensive noise burst investigations began, at DSS 13.

(2) S-band megawatt transmit (SMT) cone, with maser serial number 96S4 located in the cone, before the tricone was reconfigured into a reflex feed system, at DSS 14.

The averaged operating noise temperature calibrations for the SRO and SMT cones are summarized in Table 1. All data for the SMT cone were taken at 2295 MHz with the subreflector correctly aligned. All of the above calibration data were reduced with JPL computer program

[1]Most of these measurements were taken by DSS 13 (Venus) and DSS 14 (Mars) personnel.

5841000, CTS20B. Measurement errors of each data point average are recorded under the appropriate number in the tables. The indicated errors are the standard deviation of the individual measurements and of the means, respectively. They do not include instrumentation systematic errors. The averages were computed using only data with:

(1) Antenna at zenith.

(2) Clear weather.

(3) No RF spur in the receiver passband.

(4) Standard deviation of computed operating noise temperature due to measurement dispersion less than 0.15 K.

Figure 1 is a plot of system operating noise temperature of the SRO cone at 2278.5 MHz as a function of time in day numbers for this reporting period. In this figure data that satisfy the four conditions stated above are plotted as solid circles, while data that fail one or more conditions are plotted as open circles. Figure 2 is a similar plot which collects into one graph all of the available averaged system temperature calibrations for the SRO cone at 2278.5 MHz for the whole of calendar year 1972. It may be seen from Fig. 2 that during September the system temperature decreased on the average by more than 1 K. Table 1 shows that the average system temperature for the SRO cone at 2278.5 MHz for this reporting period, which started on October 1, 1972, was 14.9 K. This must be compared with the previous reporting periods for 1972 when the averages were: 16.4 K for June through September (Ref. 2), and 16.1 K for February through May (Ref. 3). Two changes were made to the system in September, both of which were expected to decrease the system temperature. The antenna surface was retaped, and the input section to the maser was rebuilt to counteract instabilities. The antenna retaping was expected to improve the system temperature by probably less than 0.5 K. Since the total system temperature improvement was approximately 1 K (see Fig. 2), this implies that the improvement due to the rebuilt maser input section was approximately 0.5 K.

Figure 3 is a plot of all available data for the SMT cone, both low-noise path with maser 96S4 located in the cone, and diplexed with maser 80S1 in the Mod-3 section. System temperature is plotted against time in day numbers and date for CY 1972. Figure 4 is a similar plot of all the polarization diversity S-band (PDS) cone data, both low-noise path and diplexed, for CY 1972. All data in Figs. 3 and 4 were taken at 2295 MHz. In these two figures the averaged precision measurements reduced by computer program CTS20B have been augmented by single Y-factor numbers. These data, however, were all taken with the ambient termination Y-factor method with the antenna at zenith, the subreflector correctly positioned in each case, but with no regard for weather conditions.

The subreflector and quadripod were removed from the 26-m-diam antenna at DSS 13 during November 1972. System temperature calibrations were made while the antenna, without quadripod, was pointed at zenith. These measurements were made by the Y-factor technique of switching to the ambient termination as well as using a microwave absorber over the horn. Additional data were supplied by using the Noise-Adding Radiometer (Ref. 4). All data were taken with maser 96S5 located in the SRO cone during clear weather conditions. Table 2 is a summary of the averaged system temperatures at the three operating frequencies.

Figure 5 shows antenna elevation profiles measured during October and November 1972, prior to and after the removal of the quadripod. System temperature is plotted as a function of antenna elevation angle. These data were measured with the Noise-Adding Radiometer. The solid curve was obtained prior to the quadripod removal at 2295 MHz and data points are shown for 2278.5, 2295, and 2388 MHz with no quadripod. All data in Fig. 5 were taken at 90-deg azimuth.

Figure 6 shows two antenna elevation profiles made with no quadripod on the antenna, both at 2296 MHz and 90-deg azimuth. The one curve shows data repeated from Fig. 5 for reference, and the second curve shows the profile obtained when a large reflector plate was mounted over the horn in order to direct the antenna beam over the edge of the parabola approximately at right angles to the antenna boresight axis.

The tricone system on the 64-m antenna at DSS 14 was rebuilt during January 1973. The new tricone consists of a reflex feed system to allow simultaneous S-band and X-band operation as required for the Mariner Mars 1973 S/X experiment (Refs. 5 and 6). This reflex feed system is sufficiently versatile that the reflector and dichroic plate can be retracted for normal station operation in the prereflex mode. System temperature measurements were made in January 1973 at S- and X-bands, both with the reflex feed system and with the reflex feed system retracted. These system temperature calibrations were made using the Noise-Adding Radiometer in clear weather conditions.

The lower half of Fig. 7 shows antenna elevation angle profiles at 2295 MHz with and without the reflex feed system. The cone in use was the SMT, and data are plotted as system temperatures in K versus antenna elevation angle in degrees, with the elliptical reflector extended and retracted. It must be noted that at low elevation angles the system temperature is lower in the reflex condition than it is in the original configuration. This may be seen in the upper half of Fig. 7, where the differential system temperature has been plotted as a function of elevation angle. The differential temperature is 3 K below 10-deg elevation.

Antenna elevation profiles have been plotted in Fig. 8 for 8415 MHz. These measurements were made using the multi-frequency X- and K-band (MXK) cone with the dichroic plate extended and retracted. The system operating noise temperature at 8415 MHz with the antenna at zenith is 20 K for the original system and 21.5 K for the reflex feed system.

References

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3. Reid, M. S., "Improved RF Calibration Techniques: System Operating Noise Temperature Calibrations," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. X, pp. 123–128. Jet Propulsion Laboratory, Pasadena, Calif., Aug. 15, 1972.
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Table 1. System operating noise temperature calibrations of the SRO and SMT cones

Cone and Station	SRO, DSS 13			SMT, DSS 14	
Maser serial number and configuration	96S5			80S1 Mod-3 section diplexed	96S4 Low-noise path
Frequency, MHz	2278.5	2295	2388	2295	2295
Maser gain (dB)	45.3 ±0.71/0.15 22 measurements	41.8 1 measurement	31.9 1 measurement	No measurements	47.8 ±0.85/0.60 2 measurements
Follow-up receiver contributions, K	0.29 ±0.03/0.01 18 measurements	0.45 1 measurement	0.59 1 measurement	0.10 1 measurement	0.10 1 measurement
System operating noise temperature, K	14.9 ±0.22/0.05 18 measurements	14.5 ±0.18 1 measurement	16.4 ±0.20 1 measurement	26.3 ±0.28 1 measurement	15.7 ±0.19 1 measurement

Table 2. Averaged system temperatures of SRO cone on 26-m antenna at DSS 13 with no quadripod, Nov. 1972

Frequency, MHz	Follow-up receiver contribution, K	System temperature, K
2278.5	0.3	11.6
2295	0.5	11.6
2388	0.7	13.4

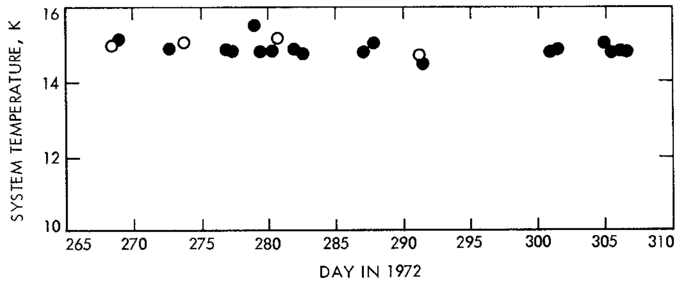

Fig. 1. System operating noise temperature calibrations of the SRO cone at 2278.5 MHz plotted as a function of time in day numbers

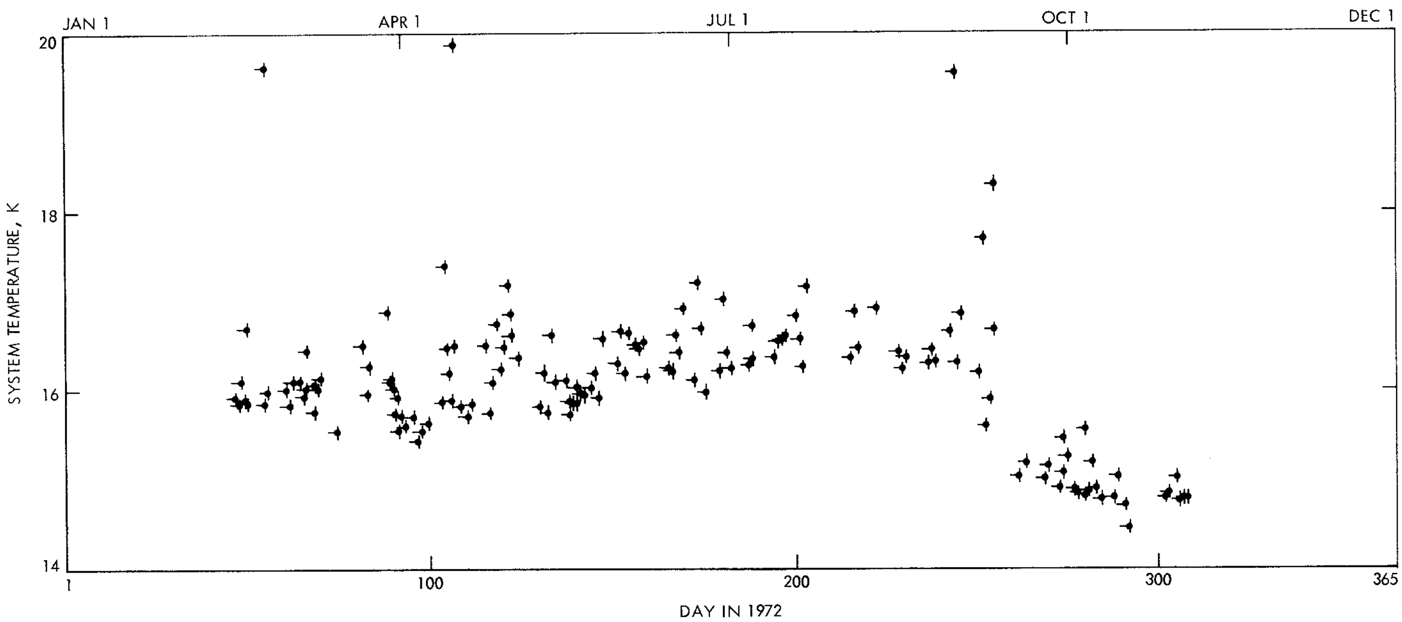

Fig. 2. System operating noise temperature calibrations of the SRO cone at 2278.5 MHz plotted as a function of time for CY 1972

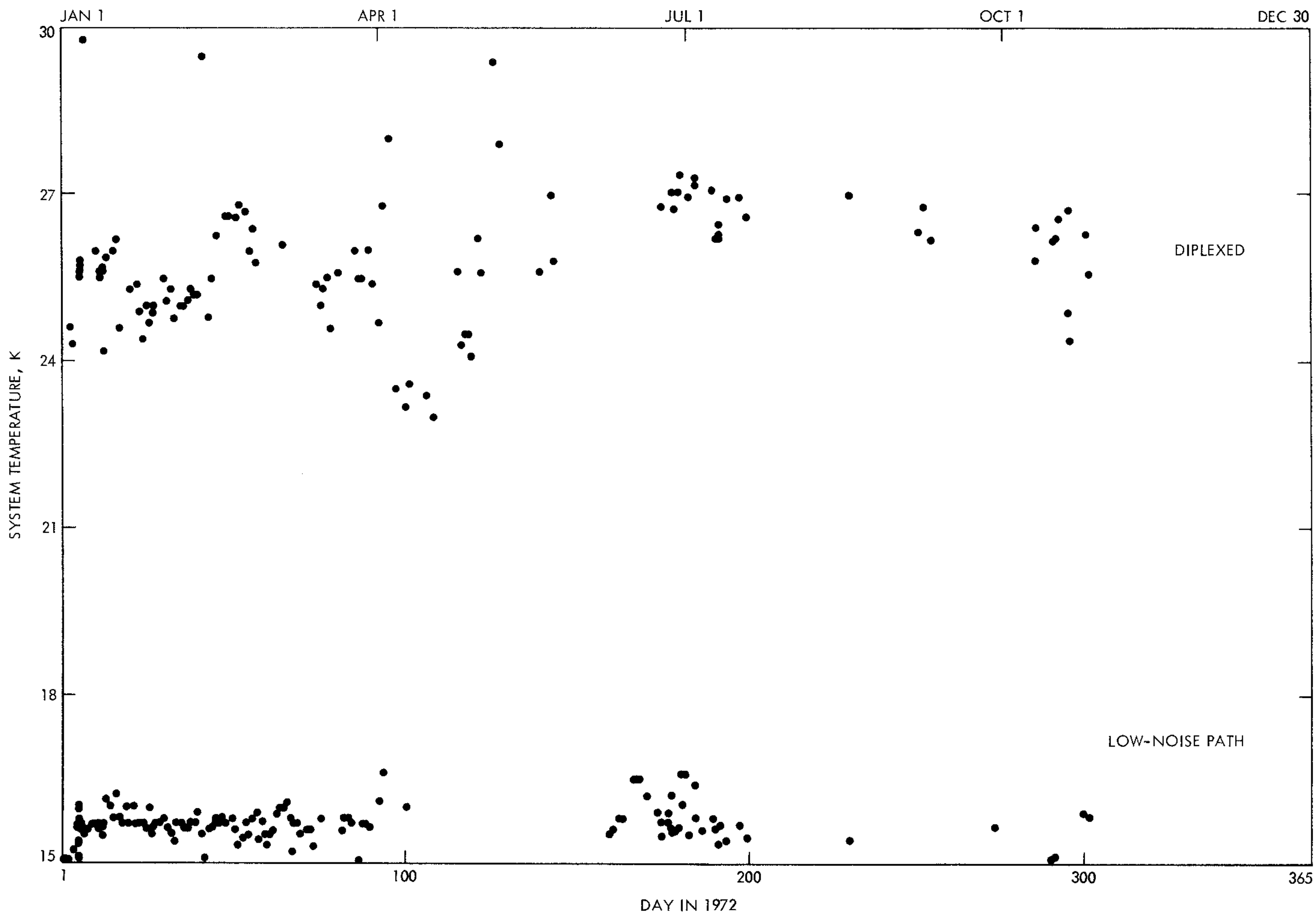

Fig. 3. System operating noise temperature calibrations of the SMT cone at 2295 MHz plotted as a function of time for CY 1972

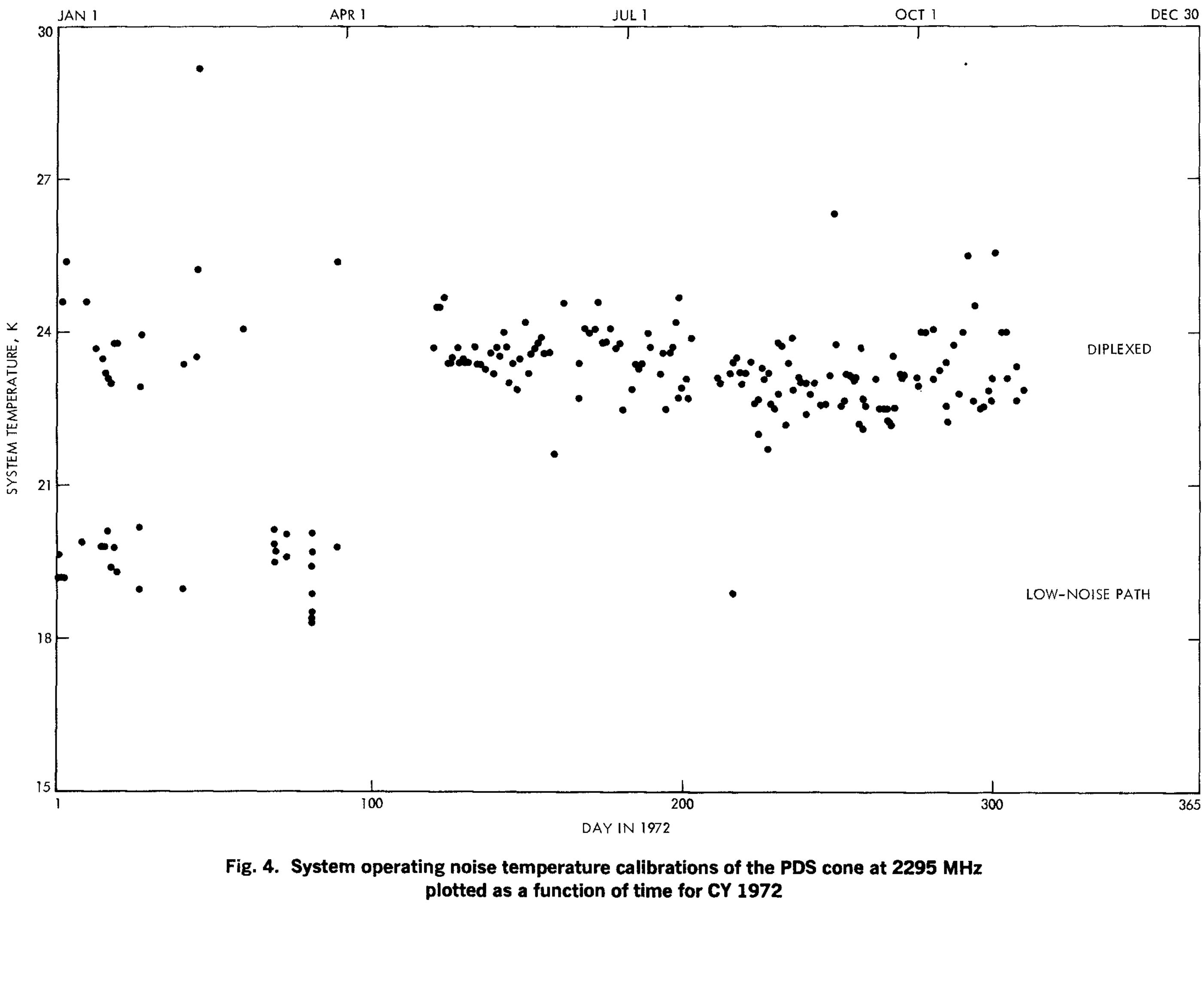

Fig. 4. System operating noise temperature calibrations of the PDS cone at 2295 MHz plotted as a function of time for CY 1972

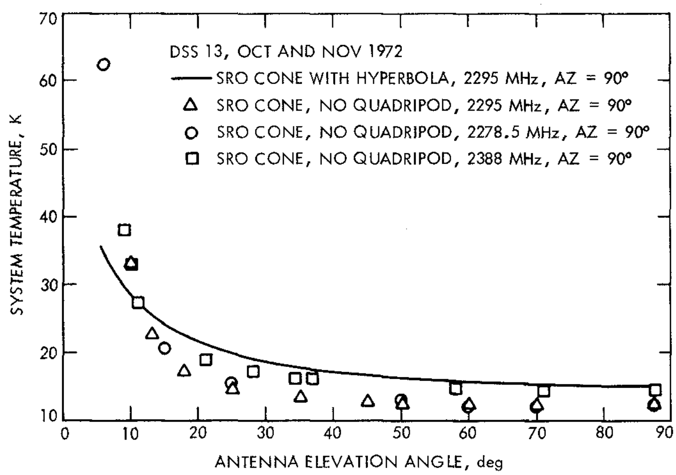

Fig. 5. Antenna elevation profiles of SRO cone with and without the quadripod

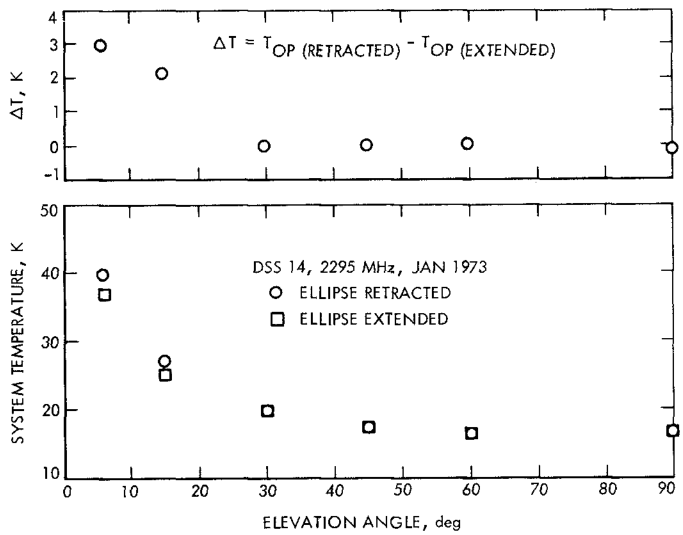

Fig. 7. Antenna elevation profiles of SMT cone with and without the reflex feed system, and the differential system temperatures

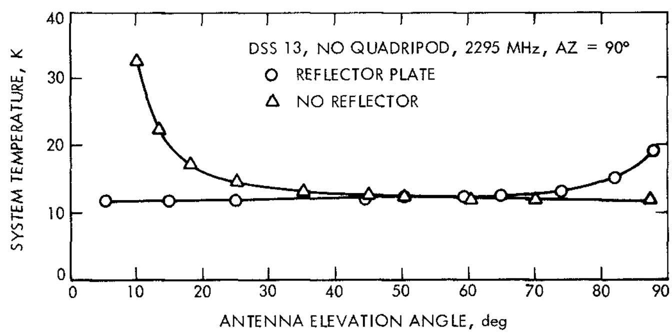

Fig. 6. Antenna elevation profiles of SRO cone with and without the reflector plate, with no quadripod

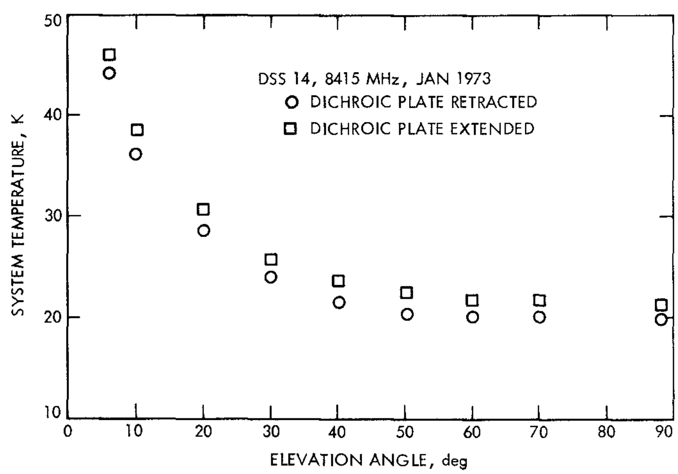

Fig. 8. Antenna elevation profiles of MXK cone with and without the dichroic plate